GLOBAL CHEMICAL FRAMEWORK AND GHS IN PAKISTAN: A POLICY ALIGNMENT REVIEW FOR BASEL, ROTTERDAM, MINAMATA CONVENTIONS, AND IMO STANDARDS FOR HAZARDOUS CHEMICALS

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Abstract

The rapid industrial growth and modern lifestyle have increased the trade of goods and chemicals transported by sea worldwide. It is one of the cost-effective transportation modes using large cargo vessels, but poor handling of chemicals and waste disposal during the operation amplifies the environmental pollution risk. It can harm the marine ecosystem, health and economy. These issues have already been addressed by numerous international agreements, such as the Basel, Rotterdam, and Minamata Conventions. The maritime rules are also defined by the International Maritime Organization (IMO) and the Globally Harmonised System (GHS), to provide guidelines for safe chemical handling. Pakistan is also a signatory to conventions and is bound to implement the laws and must align the local regulations with global standards. However, the lack of a unified legal system, weak coordination between government bodies and enforcement bodies are the major challenges for compliance with standards. This research focused on a multi-criteria policy qualitative analysis approach by integrating stakeholder consultation, document review and comparative benchmarking with the world's best practices. This review provides the major policy gaps, such as partial implementation of prior informed consent procedures, the absence of a mercury phase-out strategy and poor adoption of GHS. The compliance radar charts and stakeholder impact matrices expose the systemic weaknesses and potential areas for reform. The finding highlights the need for an integrated national strategy, improved institutional capabilities and adoption of best practices. This will strengthen the chemical safety governance and ensure sustainable maritime trade in Pakistan. This qualitative study acts as a practical guide for policymakers by outlining a clear pathway to align the national chemical management framework with global standards.

Keywords: *Maritime Trade, Hazardous Waste, Chemical Safety, MARPOL, IMO, Environment Protocols*

1. Introduction

Hazardous chemical management has become a serious concern with global industrialization and maritime trade expansion[1]. The mishandling of chemicals during transportation, storage and waste management has a catastrophic impact on the environment, including deep oceans, aquatic life, coastal zones and the atmosphere[2]. Numerous international agreements form the backbone of the Global Chemical Framework (GCF)[3]. The maritime sector is explicitly covered by the International Maritime Organization (IMO), which enforces the conventions such as International Convention for the Prevention of Pollution from Ships (MARPOL) and International Maritime Dangerous Goods **(**IMDG) code to govern the safe handling, labelling, and transportation of hazardous substances[4]. Table 1 summarizes the main goals of the conventional framework that primarily help to ensure the safe management, storage, and movement of hazardous chemicals.

Table 1. Key Objectives of the Global Chemical Management Framework.

Framework	Objective
Basel Convention	Control and reduce transboundary movement of hazardous waste and promote environmentally sound management.
Rotterdam Convention	Prior informed consent (PIC) for hazardous chemicals and pesticides in international trade.
Minamata Convention	Protect human health and the environment from anthropogenic mercury emissions and releases.
IMO Standards	Ensure safe transportation of hazardous chemicals by sea (IMDG Code) and prevent marine pollution (MARPOL Annexes).
GHS	Harmonize classification, labeling, and safety data sheets for chemicals globally.

Pakistan, being a developing country and the signatory body of conventions, makes it mandatory on itself to implement the legislations and translate the regulations into National Laws for smooth and sound import, handling, and transportation of hazardous chemicals[5]. Despite these international commitments, Pakistan continues to face significant challenges in

[1] Kaveh Ostad-Ali-Askari, "Management of risks substances and sustainable development," Applied Water Science 12, no. 4 (2022).
[2] Donat-P Häder, "Dumping of toxic waste into the oceans," in Anthropogenic pollution of aquatic ecosystems (Springer, 2021).
[3] Okeke Gerald Ndubuisi and FISPON FNisafetyE, "Assessing the Effectiveness of International Environmental Agreements in Promoting Sustainable Development and Climate Change Mitigation: A comprehensive Analysis of Global Governance Frameworks," (2025).
[4] Malgosia Fitzmaurice, "The international convention for the prevention of pollution from ships (MARPOL)," in Research Handbook on Ocean Governance Law (Edward Elgar Publishing, 2023).
[5] Urooj Bashir and Mian Tariq Javed, "Legal Avenues to Protect Environment: Investigating the Pakistan Legislation," Journal of Development and Social Sciences 6, no. 2 (2025).

translating global agreements into practical enforcement at the national level[6]. A weak institutional coordination, outdated regulatory mechanisms and fragmented responsibilities between customs, port authorities, and environmental agencies have slowed the advocacy of standardized practices such as the Globally Harmonized System (GHS)[7]. These shortcomings at the national level trigger a danger in sectors including marine trade, industrial safety and environmental protection, in addition to undermining compliance with treaties like Basel, Rotterdam, and Minamata Conventions. Therefore, Pakistan needs to find out solutions to achieve more efficient and long-lasting chemical governance, and a critical assessment of the current situation is necessary, together with insights from global best practices.

The maritime sector in Pakistan plays a vital role in the application of global chemical frameworks. The Ports, such as Karachi Port Trust and Port Qasim, manage bulk chemical imports. The Gadani ship recycling yard generates hazardous waste streams such as asbestos, oil sludge, and heavy metals. Similarly, the shipbuilding operations in Karachi, including painting processes, entail the use of welding fluxes subjected to strict compliance with GHS and IMO safety codes. Therefore, it is essential for both environmental safety and sustainable trade that Pakistan's Maritime operations comply with international chemical management standards.

The maritime industry of Pakistan is facing numerous challenges in implementing the international chemical framework. The institutional coordination, weak enforcement and gap in national legislation directly impact the compliance of Basel, Rotterdam, Minamata, GHS, and IMO standards. Therefore, this study evaluated the compliance of Pakistan with international conventions to address the hazardous chemical management at the national level. The identification of key policies, institutional gaps and benchmarks progress against the regional best practices. The objective of the study is to provide clear, evidence-based insights to address and strengthen chemical governance and ensure sustainable maritime industrial operations.

2. Literature Review

The utilization of various chemicals offers potential hazards to both the environment and the workers. The chemicals present in cleaning agents to solvents and fluxes pose a risk extending from acute toxicity to chronic health effects and environmental pollution[8]. The escalation of human activities increases the concentration of toxins in the environment along with the expansion of technologies and the developed economy[9]. Understanding the hazard and associated risk from chemicals released to the environment has grown significantly over the past 40 years[10]. The industrial production of the world has changed over the past few decades,

[6] Muhammad Afzal and Shahzada Aamir Mushtaq, "The Concept of Ratification of Treaties and Protocols in Public International Law and Their Non-Binding Effects on Developing Countries' Sovereignty: A Case Study of Pakistan," Annals of Human and Social Sciences 5, no. 3 (2024).
[7] Muhammad Jawad Akhtar, "Transforming Pakistan's Blue Economy," Policy Perspectives 21, no. 2 (2024).
[8] Nwankwo Constance Obiuto et al., "Chemical management in electronics manufacturing: Protecting worker health and the environment," World Journal of Advanced Research and Reviews 21, no. 3 (2024).
[9] Muthulakshmi Alagan et al., "Narrative of hazardous chemicals in water: its potential removal approach and health effects," Chemosphere 335 (2023).
[10] Andrew C Johnson et al., "Learning from the past and considering the future of chemicals in the environment," Science 367, no. 6476 (2020).

transforming from industrialized nations to emerging and developing countries[11]. The strict handling protocol, storage and waste disposal are critical components of a complete chemical management plan. Moreover, regulatory structure plays a determining role in shaping chemical management practices[12]. The establishment of the GHS classification and labelling of chemicals is one of the global initiatives to promote effective chemical hazard communication worldwide[13].

The international institutions are the chief controllers of the trade-environment relationship. Several of them deploy trade actions for environmental commitments. The Basel Convention, the Rotterdam Convention, and the Minamata Convention are frameworks where trade restrictions play a salient role to control the movement of hazardous matter or protect vulnerable countries from being resilient to unsafe transboundary chemical trade.[14]

2.1 Global Chemical Management Framework

Global chemical management frameworks provide internationally accepted guidelines for the safe handling, trade and disposal of hazardous substances. The Basel, Rotterdam, and Minamata Conventions collectively aim to protect human health and the surrounding environment from the adverse effects of dangerous chemicals and their waste. The Basel Convention was accepted in 1989 by the conference of diplomats in Switzerland, and enforced in 1992, with 187 countries as signatories to this convention.[15] It was the first legal instrument around the world that offered legally obligatory rules for global hazardous waste management and trade[16]. Building on this foundation, an essential step for highly toxic chemicals to protect humans and the environment, the Rotterdam Convention was adopted in 1998. This convention helps to monitor and control trade in hazardous substances, circulate better information about health and environmental issues of chemicals and prevent unnecessary imports of hazardous chemicals[17]. The Minamata Convention on Mercury was adopted in 2013 and enacted in 2017[18]. To protect human health and the environment, the Minamata Convention is a global treaty to put the brake on anthropogenic releases of Mercury[19]. Each convention comprises

[11] Alagan et al., "Narrative of hazardous chemicals in water: its potential removal approach and health effects."
[12] Obiuto et al., "Chemical management in electronics manufacturing: Protecting worker health and the environment."
[13] Goh Choo Ta, "GHS Implementation to Strengthen Global Chemical Hazard Communication: Will We Ever Get There?," ACS Chemical Health & Safety 28, no. 3 (2021).
[14] Joshua O Babayemi, Innocent C Nnorom, and Roland Weber, "Initial assessment of imports of chlorinated paraffins into Nigeria and the need of improvement of the Stockholm and Rotterdam Conventions," Emerging Contaminants 8 (2022).
[15] Akhtar, "Transforming Pakistan's Blue Economy."; Shiming Yang, "Trade for the environment: Transboundary hazardous waste movements after the Basel Convention," *Review of Policy Research* 37, no. 5 (2020).
[16] Alexandra Korcheva, "Basel convention on the control of hazardous wastes," in Encyclopedia of Sustainable Management (Springer, 2023).
[17] Barbara Dinham, "Laws and Regulations: Rotterdam Convention," in *Managing Human and Social Systems* (CRC Press, 2020).
[18] Reiko Sodeno, "Analysis of the Minamata Convention on Mercury in the Context of Sustainable Development Goals (SDGs)," *Global Environmental Research* (2020).
[19] Takeshi Fujiwara and Masaki Takaoka, "The response of anthropogenic mercury release in China to the Minamata Convention on Mercury: A hypothetical expectation," *Journal of Cleaner Production* 323 (2021).

rules that regulate the production, application, trade, and disposal of substances, as well as constraints on emissions of by-products and requirements of regular assessment[20].

2.2 Pakistan's Commitment and Current Status

Marine ecosystems play a crucial role in human life, development, and health, thereby encouraging sustainable development. However, due to rapid urbanization and industrialization, as well as intense exploitation of marine resources, the deterioration has been observed in ecosystem diversity[21]. Although Pakistan has ratified major international conventions and is a signatory body in the Basel, Rotterdam, Minamata Conventions and has also endorsed the Globally Harmonized System (GHS), the translation of these commitments into practice has been inconsistent[22]. Federal and provincial regulations are mostly outdated or fragmented. The Rotterdam Convention prior informed consent procedure is only partially implemented, while Minamata's mercury phase-out requirements still lack the national inventory. The pilot initiatives in Punjab and Sindh have started the implementation of GHS, although nationwide integration into industrial practices has yet to be accomplished. This uneven progress illustrates the gap between Pakistan's international obligations and its domestic enforcement capacity[23].

2.3 International Best Practices

The international best practices are available to adopt from Asian and European countries. India has created a centralized inventory of chemicals and set up poison information centres, enhancing its national ability for risk communication and emergency response. Japan has effectively linked these standards with port inspection procedure and include GHS criteria in its safety data sheets and labelling system[24]. European countries (Belgium and France) have strict bans on hazardous pesticides, whereas Italy and the Netherland promote the Integrated Pest Management (IPM). These experiences demonstrate that aligning legal frameworks with practical enforcement mechanisms can be achievable with dedicated support by institutional coordination and technological investment.

2.4 Maritime sector linkages in Pakistan.

A critical interference between international chemical governance frameworks and their practical enforcement has been represented by the maritime sector of Pakistan. The Ports, ship recycling yards, and shipbuilding facilities oversee a substantial volume of hazardous

[20] Maximilian Häntzschel, "Toxic Remnants of War-exploring the limits of the Basel, Rotterdam and Stockholm Conventions" (Itä-Suomen yliopisto, 2023).
[21] Asif Khan and Maseeh Ullah, "The Pakistan-China FTA: legal challenges and solutions for marine environmental protection," *Frontiers in Marine Science* 11 (2024).
[22] Akhtar, "Transforming Pakistan's Blue Economy."; Asif Mehmood Butt, "To safeguard GSP Plus status, Pakistan steps up hazardous waste, chemical safety action. ," *The News International* (Lahore, Pakistan), 14 January 2025 2025.
[23] UNEP, *Strengthening of national legislation and capacity building of stakeholders for sound chemicals and hazardous waste management in Pakistan* (2024).
[24] Hiroshi Jonai, "Impact of the GHS on Chemical Management in Japan," *ACS Chemical Health & Safety* 28, no. 5 (2021).

chemicals and materials that fall directly under the orbit of Basel, Rotterdam, Minamata Conventions, IMO standards, and GHS protocols. However, the level of compliance and institutional readiness within the sector remains limited, with significant environmental and occupational safety concerns.

2.4.1 Ship Recycling.

One of the largest ship recycling facilities in the world is hosted by Pakistan, the Gadani ship-breaking yard. The operation of ship dismantling produces various types of hazardous waste, potential asbestos hazards, Polychlorinated Biphenyls (PCBs), heavy metals, sludge and oil spills. The Basel agreements rigorously control cross-border transport and the eco-friendly disposal of this waste. However, Pakistan's regulatory supervision of Gadani is still inadequate. Toxic materials are frequently discharged into the marine environment without proper management. The workers' safety measures are also not aligned with GHS and IMO conventions for safe and eco-friendly ship recycling.

2.4.2 Port Operations.

The port of Pakistan handled large shipments of petroleum products, industrial chemicals, fertilizers and pesticides for both imports and exports. Compliance with the IMO's IMDG code and MARPOL Annex-III is crucial for preventing accidents, protecting the marine environment, and reducing the fire risk. Stakeholders' consolidation uncovered deficiencies in the separated storage facility, inadequate firefighting resources and an absence of trained hazardous materials response teams at Karachi and Port Qasim. The lack of a centralised chemical inventory makes monitoring and enforcement more challenging.

2.4.3 Shipbuilding and Repair.

The establishment for building and repairing ships in Pakistan is led by the Karachi Shipyard Engineering Works. This manufacturing industry uses a wide range of construction fluxes, solvents, lubricants, coatings and cleaning products with high chemical risk due to mishandling and lack of training. The incorporation of GHS standards with regular training and audit can improve the shipyard safety and encourage the national dedication for chemical management.

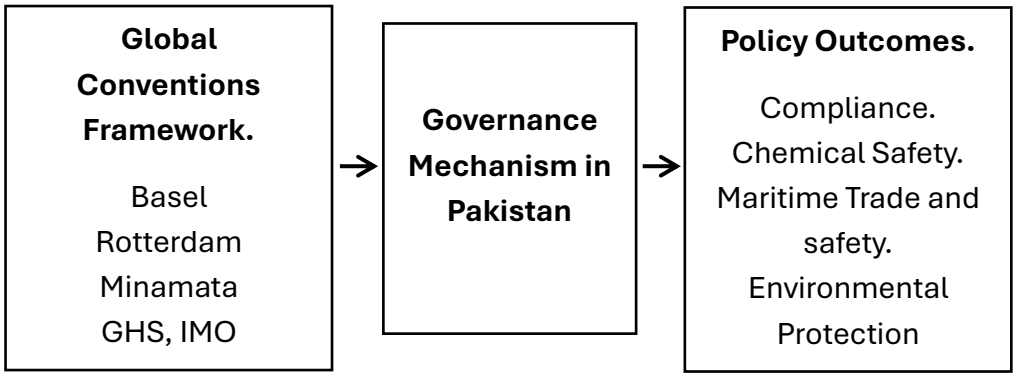

Figure 1. Conceptual framework: the relationship between conventions, governance mechanisms, and policy outcomes.

3. Methodology

The framework for the review study was qualitative, multi-criteria policy analysis and integrated the document review, stakeholder engagement, comparative evaluation, and visual plotting. The qualitative approach allows in-depth understanding of legal, institutional, and policy frameworks, which cannot be captured through numerical data alone. The method identified both progress and practical challenges in implementing international conventions in Pakistan. The agenda of this approach was to evaluate and assess how far Pakistan's chemical management system has progressed in aligning itself with international commitments and global best practices.

3.1 Data Collection & Analysis.

The international conventions, national laws, reports, and peer-reviewed articles were reviewed. Stakeholder's consultation involved experts from government regulatory bodies, environmental experts, and industry representatives. Comparative data from other countries were also included to benchmark Pakistan's progress against global practices. The selection was entirely based on the knowledge or experience that would aid the results in the most precise manner, as well as the implementation of the laws with ease. The legal alignment, institutional capacity and implementation challenges were the broader categories in which the collected data were decoded. The score 0-5 was generated from the selected. Average scores were calculated and converted to form a radar chart. This study is subject to certain limitations. Researcher bias may have influenced the interpretation of qualitative data. Additionally, the availability and comprehensiveness of documents varied, and stakeholder responses were sometimes inconsistent or incomplete. Finally, the findings are context-specific to Pakistan and may not be directly generalizable to other countries.

3.2 Document Review and Legal Mapping

Initially, a thorough examination of international agreements, domestic laws and regulatory structures linked to chemical safety directly or indirectly. The Basel, Rotterdam, Stockholm and Minamata conventions official documents were also reviewed, along with GHS implementation procedures released by organizations such as United Nations Institute for Training & Research (UNITAR) and United Nations Economic Commissions for Europe (UNECE). The maritime safety regulations were assessed via IMO conventions such as Hazardous and Noxious Substances Convention, MARPOL and International Maritime Dangerous Goods Code. The national document of Pakistan Environmental Protection Act (1997), the national chemical safety policy and import policy order (2022) were examined to assess the incorporation of global standards into local legislation. The document was summarized to address the compliance monitoring, port safety, risk communication and institutional responsibilities systematically.

3.3 Stakeholder Mapping and Expert Consultation

In addition to the document analysis, discussions with important stakeholders were conducted. This consisted of government officials, port regulators, customs and experts engaged in hazardous waste management. Federal and Provincial Environmental Protection Agency (EPA) officials, along with representatives from the Port Qasim Authority and Karachi Port Trust, were also interviewed to gain insight into port institutional practices. The meeting was scheduled with hazardous waste supervisors, customs officials and experts from NGOs

experienced in chemical management. A total of 20 people were selected using purposive sampling. The individuals actively involved in chemical safety participated in the survey to ensure data accuracy. The input from selected stakeholders was comprehensively examined to pinpoint institutional readiness, capacity gaps and coordination challenges. Their perspective helps in understanding essential context in policy analysis, particularly by highlighting actual challenges such as ineffective interagency communication, insufficient laboratory resources and lack of qualified staff.

3.4 Policy Gap Analysis and Comparative Benchmarking

A policy gap was analysed to evaluate the effectiveness of existing framework of Pakistan in comparison with international obligation. A metric was created to assess the quality of compliance reports, the integration of treaty obligations into domestic law, the existence of a structured enforcement system and the general ability to implement an emergency response. A set of benchmarks was defined using scored system such as, 2 = fully addressed, 1 = partially addressed, 0 = Not addressed. No weighting was applied, each criteria were considered equally important for evaluating progress. This analysis depicts the comparative assessment of Pakistan's existing situation in comparison with Southeast Asian countries due to their successful compliance with GHS, chemical databases and port audit systems. This provide the comparative analysis of weak areas and oversight policies to adopt the global standards by Pakistan.

3.5 Graphical Synthesis and Impact Mapping

The radar chart was used to map the findings and present the outcomes of research. A chart was developed to present the degree of consistency between selected conventions. A metric system was used to understand the stakeholder influence and impact. This also help to determine the agencies with higher influence and lower impact due to limitations. A graphical representation also emphasized the association between maritime authorities, customs and environmental agencies. These tools successfully elucidated complex connection and also highlight the weak areas where changes could be more effective.

3.6 Overall Approach

The stakeholder views, reports, comparative benchmarks and visual aids confirm the comprehensive assessment of hazardous chemical management in Pakistan. The study has covered the Pakistan legal obligation under the international agreement and its implementation within port, customs and environmental regulations. The recommendations are based on data-supporting analysis and suggest technically sound and contextually relevant modifications. Therefore, the mixed-method research assesses the Pakistan institutional capacity and policy alignment with global standards in chemical safety.

4. Results and Discussion

4.1 Pakistan’s coordination with the Conventions

The Basel Convention, Rotterdam, and the Minamata Agreement, along with the GHS guidance and countries’ policies, the gaps manifest as disconnect between intention and action. The country ratified Minamata in December 2020, which, in principle, should have triggered Mercury management controls, inventories and phased-out planning. Although documents also

express these elements to be planned, the actual execution is lacking. The National Hazardous Waste Management Policy (NHWMP) 2022 was framed as a life cycle concern to hazardous waste management and incorporates a few elements of Pakistan's International obligations, which can be considered as a significant anchor of domestic alignment. Simultaneously, a United Nations Environmental program (UNEP) special programme project was outlining steps to facilitate implementation. These suggest that a part of policy integration has already been initiated through building capacity rather than a single comprehensive law.

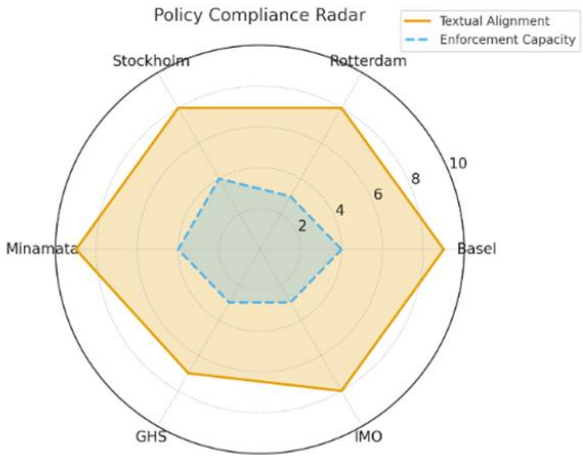

Figure 2. Policy compliance radar map for comparative analysis.

Figure 2 shows a policy compliance radar chart that compare different international agreements and standards followed in Pakistan. These include the Basel, Rotterdam, Stockholm, Minamata Conventions, GHS and the IMO guidelines. A radar map was created on a sample of twenty stakeholders, such as government officials, industry representatives, and environmental experts. Certainly, the targeted sample is even smaller, expanding the sampling will change the comparative analysis, but it the usual approach that defines the study on which 20 industry experts' opinions are reasonably expected to highlight common patterns and areas demanding improvement in policy compliance[25]. However, future research could include a larger sample into segregating it into subcategories or more from various industries to make the findings more dependable. The results show that agreements like the Basel Convention on hazardous waste, and where there is less consistency, such as with the Minamata Convention and GHS.

In the analysis aspect of the maritime sector, which significantly contributes a portion of the country's GDP, these are going to managing chemicals and lowering greenhouse gas emissions, e.g., Ship recycling, port operation, and ship construction produce harmful waste and residue resulting in elevated emissions and safety hazards for employees and employers. This study demonstrates the connection between international agreements and IMO regulations through the inclusion of the maritime sector, particularly in recycling, port operation, specifically handling asbestos and heavy metals. This conceptual framework has a broader

[25] Suresh K Sharma et al., "Navigating sample size estimation for qualitative research," Journal of Medical Evidence 5, no. 2 (2024).

perspective that enables us to redirect, as in Figure 1, which provides a comprehensive overview of how effective Pakistan policies are aligned with international standards, with its regional and international activities.

- Rotterdam Convention obligation, particularly prior informed consent procedures for import of banned pesticides, shows a low transposition rate of 42%, directing fragile regulatory enforcement.
- 54% of core legal provisions under the Basel Convention (related to hazardous waste import/export procedures and disposal protocols) have been integrated into national laws.
- The partial integration of mercury phase-out is ruled by Minamata Convention. Pakistan lacks a regulatory restrictions and a mercury inventory on mercury-added products.
- GHS implementation remains in the preliminary stage at the national level. The provinces of Punjab and Sindh have introduced pilot-scale implementation under technical assistance from UNITAR, with limited industry outreach and training.

The analytical point of disarrangement indicates that the current governance system and enforcement mechanisms are inactive, with a lack of integration between institutions with an absence of coordination mechanisms. If the same continues at this pace, a struggle will remain there to meet its global treaty obligations.

4.2 Comparative Analysis with International Practices.

In contrast with other countries in the region, the chemical labelling and inventory system in Pakistan shows a poor practices and compliance. A case study of Bangladesh Chemical Health and Safety 2020 provides a comprehensive plan for a chemical management system and outlines robust inventory tracking, concerned department roles and tools for ensuring compliance[26]. This shows what a powerful system may look like in a similar developing country on the industry level. Pakistan's own Process Safety Management /Process Handling Safety studies highlight issues like missing documents, poor communication, and uneven hazard assessment across refineries and chemical plants[27].

Table 2. Pakistan's Current Legal Framework compared to the International Framework.

Aspect	Pakistan Regulation	Basel	Rotterdam	Minamata	IMO	GHS
Hazardous Waste Control	Pakistan Environmental Protection Act 1997, NEQS	✓	✕	✕	Partial	✕
PIC for Chemical Trade	No specific law	✕	✓	✕	✕	✕

[26] Amit Hasan Anik, Mohammad Toha, and Shafi M Tareq, "Occupational chemical safety and management: A case study to identify best practices for sustainable advancement of Bangladesh," Hygiene and Environmental Health Advances 12 (2024).

[27] Ta, "GHS Implementation to Strengthen Global Chemical Hazard Communication: Will We Ever Get There?."

Mercury Emission Control	No national mercury regulation	✕	✕	✓	✕	✕
Marine Transport Safety	Merchant Shipping Ordinance 2001	✕	✕	✕	✓	✕
Chemical Labeling & SDS	No GHS adoption yet	✕	✕	✕	✕	✓

Table 2 summarize the main aspects, existence of local regulation and compliance of Pakistan to fully adopt the GHS system. The global framework and policies are in place; the adoption and implementation are needed for effective outcomes and alignment with standards. The development of inventories, consistent SDS practices, and infant inspection is still lagging compared to other regional countries.

The comparative gaps show that Pakistan must shift from signatory to policy affirmation, an urgent need to fill the gap in institutional capacity, sector scaling, monitoring, and institutional accountability to meet regional standards.

4.3 Maritime Sector Challenges in Chemical Governance.

The result of this study indicates that Pakistan's maritime industry is among the most vulnerable aspects in implementing international chemical management obligations effectively. The consultation with stakeholders revealed that ports, ship recycling yards and shipbuilding facilities encounter ongoing structural and institutional challenges in adhering to the Basel, Rotterdam and Minamata conventions, along with the IMO and GHS frameworks.

Although Gadani is one of the major centres for ship recycling worldwide, it still functions with minimal environmental regulation. Hazardous waste such as oil by-products, asbestos and heavy metals is frequently discharged into the marine environment without adequate treatment, violating Basel Convention principles. The employees indicated limited availability of personal protective equipment and are not aware of the chemical hazard communication aligned with GHS guidelines. This practice put human health and the coastal ecosystem at considerable risk and incidents at the yard highlighted the flaws in the monitoring and enforcement system.

The shipbuilding industry indicates some awareness but lacks in strong enforcement of chemical safety measures. Welding chemicals and solvents are extensively utilized without uniform labelling, proper storage and SDS safety data sheets required by GHS. The lack of consistent training underscores weaknesses in institutional capacity and strengthens the stakeholder's view that Pakistan's issue is not defining policies but, in their execution, and implementation.

Alternatively, where port authorities manage large volumes of imported and exported chemicals, the infrastructure for compliance with IMDG code and MARPOL Annex-III is inadequate. Stakeholders are exposed to insufficient segregated storage and a lack of resolute hazardous materials response units. It was also highlighted that the absence of a centralised digital chemical inventory makes it much more challenging to track shipments and ensure consistency with conventions like Rotterdam's prior informed consent requirements.

The challenges imply that without targeted improvements in port governance, hazardous waste management, and IMO compliance. The country risk international trade barriers, environmental recompensation, and persistent occupational hazards in the maritime sector.

4.4 Stakeholders Perception

The stakeholder consultation highlighted that the Pakistan main problem is not creating policies but to adopt them at ground level and implement accordingly. The environmental experts at the national and provincial level know about Pakistan's duties under the Basel, Rotterdam and Minamata Conventions as well as IMO and GHS. But lack of enough staff, skills and awareness discourage the professionals to follow the regulation and implement for compliance. Table 3 shows the comparison of multiple implementation challenges in convention sectors, ranging from high to low.

Table 3. Comparison of Implementation Challenge

Challenge	Basel	Rotterdam	Minamata	IMO	GHS
Legislative Gaps	High	High	High	Medium	High
Institutional Capacity	Medium	Medium	High	Medium	High
Technical Expertise	High	High	High	Medium	High
Monitoring & Enforcement	High	High	High	High	High

The port officials and customs also worried about chemical imports not having proper labelling as required by GHS standards and the absence of a single list of chemicals. This results in poor handling of chemicals by workers. On the other hand, stakeholders with both high influence and high impact suggest that the Ministry of Climate Change and the Environmental Protection Agency directly shape compliance and enforcement.

United Nations-linked organizations and non-governmental groups highlight poor teamwork as a major problem in implementing standards. There is no clear mechanism for communication between the department and various groups with zero accountability. Figure 3 represents the organizational setup appeared scattered, which seemed to make some areas less effective, whereas others were managed relatively well. Despite these challenges, the involved stakeholders are hopeful. They believed that recent initiatives, such as the introduction of new policies and training sessions, may bring gradual change. This can also be enhanced by consistent support and political commitment at the national level. These efforts would encourage the staff to understand the proper chemical handling, implement standards at the workplace and fully comply with regulations.

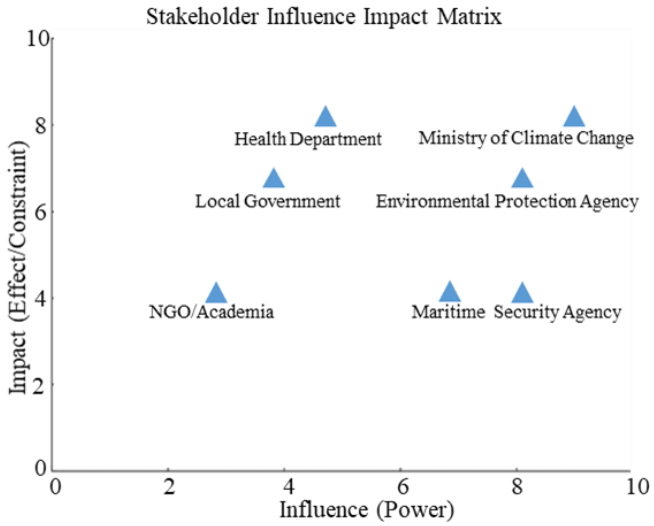

Figure 3. Stakeholder influence (power) vs Impact (Effect)

4.5 Recommendations for Policy and Institutional Reforms.

The results support the urgent calls for action for the establishment of the National Chemical Safety Council to harmonize the coordination between different sectors, adoption of GHS across the industries with incentives for compliance, development of a national mercury inventory and roadmap for phase-out of each Minamata requirement, and digitization of chemical import/export permits integrated with customs declaration and EPA oversight. These recommendations will upgrade the Pakistan governance system for capacity building and policy implementation.

5. Conclusion.

Stakeholder coordination and policy alignment are two key aspects that underscore the importance of national chemical management. Pakistan has performed well in adhering to agreements such as Basel and Rotterdam Convention. The major gap was found for the Minamata and GHS. The differences indicate that the various aspects of chemical control are being implemented and regulated at varying rates. Moreover, a matrix examining the influence and impact of various groups reveals an imbalance; some groups exercise significant influence with minimal power, whereas others possess considerable impact but restricted authority. In conclusion, the research indicates that genuine advancement in the effective and consistent management of chemicals will arise from improved adherence to international regulations and enhanced collaboration with the nation. In the future, Pakistan's capacity to enhance its chemical authority will rely on investing in institutional capabilities on ongoing political dedication and creating integrated national systems that facilitate long-term alignment with international standards.

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Data Availability
The data that support the findings of this study are available from the corresponding author upon reasonable request.

Conflicts of Interest
The authors declare that they have no conflict of interest.

References

Afzal, Muhammad, and Shahzada Aamir Mushtaq. "The Concept of Ratification of Treaties and Protocols in Public International Law and Their Non-Binding Effects on Developing Countries' Sovereignty: A Case Study of Pakistan." Annals of Human and Social Scienceces 5, no. 3 (2024): 546-59.

Akhtar, Muhammad Jawad. "Transforming Pakistan's Blue Economy." Policy Perspectives 21, no. 2 (2024): 133-53.

Alagan, Muthulakshmi, Somasundaram Chandra Kishore, Suguna Perumal, Devaraj Manoj, Atchudan Raji, Raju Suresh Kumar, Abdulrahman I Almansour, and Yong Rok Lee. "Narrative of Hazardous Chemicals in Water: Its Potential Removal Approach and Health Effects." Chemosphere 335 (2023): 139178.

Anik, Amit Hasan, Mohammad Toha, and Shafi M Tareq. "Occupational Chemical Safety and Management: A Case Study to Identify Best Practices for Sustainable Advancement of Bangladesh." Hygiene and Environmental Health Advances 12 (2024): 100110.

Babayemi, Joshua O, Innocent C Nnorom, and Roland Weber. "Initial Assessment of Imports of Chlorinated Paraffins into Nigeria and the Need for Improvement of the Stockholm and Rotterdam Conventions." Emerging Contaminants 8 (2022): 360-70.

Bashir, Urooj, and Mian Tariq Javed. "Legal Avenues to Protect the Environment: Investigating the Pakistan Legislation." Journal of Development and Social Sciences 6, no. 2 (2025): 430-38.

Butt, Asif Mehmood. "To Safeguard Gsp Plus Status, Pakistan Steps up Hazardous Waste, Chemical Safety Action. ." The News International (Lahore, Pakistan), 14 January 2025 2025.

Dinham, Barbara. "Laws and Regulations: Rotterdam Convention." In Managing Human and Social Systems, 389-93: CRC Press, 2020.

Fitzmaurice, Malgosia. "The International Convention for the Prevention of Pollution from Ships (Marpol)." In Research Handbook on Ocean Governance Law, 91-108: Edward Elgar Publishing, 2023.

Fujiwara, Takeshi, and Masaki Takaoka. "The Response of Anthropogenic Mercury Release in China to the Minamata Convention on Mercury: A Hypothetical Expectation." Journal of Cleaner Production 323 (2021): 129089.

Häder, Donat-P. "Dumping of Toxic Waste into the Oceans." In Anthropogenic Pollution of Aquatic Ecosystems, 353-71: Springer, 2021.

Häntzschel, Maximilian. "Toxic Remnants of War-Exploring the Limits of the Basel, Rotterdam and Stockholm Conventions." Itä-Suomen yliopisto, 2023.

ILO. Safe and Environmentally Sound Ship Recycling and Decent Work (Sensrec-Dw) in Pakistan. (2025).

Johnson, Andrew C, Xiaowei Jin, Norihide Nakada, and John P Sumpter. "Learning from the Past and Considering the Future of Chemicals in the Environment." Science 367, no. 6476 (2020): 384-87.

Jonai, Hiroshi. "Impact of the Ghs on Chemical Management in Japan." ACS Chemical Health & Safety 28, no. 5 (2021): 320-25.

Khan, Asif, and Maseeh Ullah. "The Pakistan-China Fta: Legal Challenges and Solutions for Marine Environmental Protection." Frontiers in Marine Science 11 (2024): 1478669.

Korcheva, Alexandra. "Basel Convention on the Control of Hazardous Wastes." In Encyclopedia of Sustainable Management, 235-39: Springer, 2023.

Ndubuisi, Okeke Gerald, and FISPON FNisafetyE. "Assessing the Effectiveness of International Environmental Agreements in Promoting Sustainable Development and

Climate Change Mitigation: A Comprehensive Analysis of Global Governance Frameworks." (2025).

Obiuto, Nwankwo Constance, Kehinde Andrew Olu-lawal, Emmanuel Chigozie Ani, and N Ninduwezuor-Ehiobu. "Chemical Management in Electronics Manufacturing: Protecting Worker Health and the Environment." World Journal of Advanced Research and Reviews 21, no. 3 (2024): 010-18.

Ostad-Ali-Askari, Kaveh. "Management of Risks Substances and Sustainable Development." Applied Water Science 12, no. 4 (2022): 65.

Sharma, Suresh K, Shiv Kumar Mudgal, Rakhi Gaur, Jitender Chaturvedi, Satyaveer Rulaniya, and Priya Sharma. "Navigating Sample Size Estimation for Qualitative Research." Journal of Medical Evidence 5, no. 2 (2024): 133-39.

Sodeno, Reiko. "Analysis of the Minamata Convention on Mercury in the Context of Sustainable Development Goals (Sdgs)." Global Environmental Research (2020).

Ta, Goh Choo. "Ghs Implementation to Strengthen Global Chemical Hazard Communication: Will We Ever Get There?". ACS Chemical Health & Safety 28, no. 3 (2021): 153-58.

UNEP. Strengthening of National Legislation and Capacity Building of Stakeholders for Sound Chemicals and Hazardous Waste Management in Pakistan. (2024).

Wang, Zhanyun, Glen W Walker, Derek CG Muir, and Kakuko Nagatani-Yoshida. "Toward a Global Understanding of Chemical Pollution: A First Comprehensive Analysis of National and Regional Chemical Inventories." Environmental science & technology 54, no. 5 (2020): 2575-84.

Yang, Shiming. "Trade for the Environment: Transboundary Hazardous Waste Movements after the Basel Convention." Review of Policy Research 37, no. 5 (2020): 713-38.